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MONITORING THE INCUBATION BEHAVIOUR OF THE HOUBARA *CHLAMYDOTIS UNDULATA* WITH A TEMPERATURE LOGGER DUMMY EGG[1]

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(*With two text-figures and one plate*)

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The incubating behaviour of two female houbara was successfully monitored with the help of a temperature logger egg from May 22 to June 11, 1999 in the Xinjiang province of the People's Republic of China. As a rule, the female showed a bimodal daily activity pattern (morning and evening) during the incubation stage. On an average, a female will leave her nest 3 to 9 times daily for periods ranging from 8 to 26 minutes, but will spend an overall 94±2% of her daily time on the nest. The average daily temperature of the egg, when the female attended the nest, varied from 31.9 °C to 36.5 °C. When the female left the nest unattended, the temperature of the egg generally dropped to an average minimum of 24.9 °C, but could also rise to 40.6 °C (absolute maximum) in hot conditions. Following the seasonal increase in daily air temperature as summer progressed, the average daily egg temperature increased from 31.9 °C to 36.2 °C as the incubation advanced.

Introduction

For several years, the National Avian Research Centre (NARC) in Abu Dhabi has been developing an ambitious project aimed at defining a conservation and management strategy for the Asiatic subspecies of the houbara, *Chlamydotis undulata*, based on sound scientific knowledge of its population dynamics (Launay 1998). A houbara caught in Abu Dhabi, and followed by satellite tracking, migrated to the centre of China in spring and summer 1997. With these in mind, a three-year agreement between NARC and the Xinjiang Institute of Ecology and Geography, People's Republic of China, was started in 1997. The agreement focuses on the study of the breeding biology, migration and the implementation of pluri-annual surveys to monitor the general trends in the population.

Despite the high conservation profile of the houbara, there are few ecological studies conducted in the wild. In particular, information on the egg temperature and activity rhythm of the houbara in the wild is very limited in the literature, and many aspects remain unknown. Some information on the feeding activity of the incubating female was collected by Gaucher (unpubl. data) in Algeria, and a preliminary observation of the incubation behaviour was conducted by Launay *et al.* (1997) in Uzbekistan.

This study was conducted with a temperature logger inserted in an egg and added to a nest clutch in the wild. The logger presented

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information on the changes in the egg temperature and on the activity rhythm of the incubating female.

Study Area and Method

The study was conducted from April 27 to July 15, 1999 by a team from the National Avian Research Centre (UAE) and the Xinjiang Institute of Ecology and Geography (China).

The study area is located in the semi-desert steppes of the eastern fringe of the Jungar Basin, Xinjiang Province of the People's Republic of China. The area was chosen on the basis of previous observations of houbara breeding (Gao *et al.* 1997). It is a high plateau bordered by the Tian Shan Mountains to the south and complex sand dunes to the north. The substrate is predominantly clay and gravel to the south, changing to sand towards the north. The topography of the area varies from flat to slightly undulating. Various associations of *Artemisia* sp., *Anabasis* sp., and *Ceratoides* sp. dominate the vegetation in the area. This vegetation is typically short (5-10 cm). Irregular bushy formations of *Salsola* sp. and *Haloxylon* sp. occur sparingly. More than twenty ephemeral plant species, including *Plantago* sp., *Lepidium* sp., *Ceratocarpus* sp., *Tulipa* sp., *Scorzonera* sp., and *Corydalis* sp. commonly occur in early spring following precipitation. The overall plant cover lies typically within 10 to 20%.

Information on incubation behaviour was obtained by means of a dummy egg containing a temperature logger. One infertile egg from a natural nest was cut open and drained, and the temperature logger was fitted inside with cotton wool. The two halves were then glued together. The data logger was a Stow Away TidbiT Temp logger (TBI32) made by ANSET (USA) with a ±0.4 °C accuracy. The logger can operate from -30 °C to 70 °C. It was set to take one reading every two minutes, which allowed for 24 days of monitoring. The logger was downloaded to a computer once at the end of the study.

The air temperature was recorded twice a day, at 0700 hrs and 1400 hrs, and was compared with the temperature of the logger egg when the female left the nest.

We studied the effect of disturbance by cars on the behaviour of the incubating female. All the cars were equipped with a GPS set to record the track routes, which were downloaded to a computer every alternate day. The track routes were then compared to the nest locations and the effect on the females' behaviour was assessed through the changes in egg temperature following our visits to the nests. The temperature was assessed when the car approached the nest, giving another 15 minutes to allow the egg to cool after the female left the nest.

Results and Discussion

The temperature logger egg was placed successively inside two nests, which had already been in incubation. It was left in the nest until the hatching of the natural eggs. From May 22 to 28 (5 complete days), the egg was placed in a nest of 4 eggs and then moved to a nest of 5 eggs from May 28 to June 11 (12 complete days).

Incubation behaviour: We observed a decrease or series of decreases in the temperature of the egg in the early mornings and evenings (Fig.1A-E). This was interpreted as the time when the female left the nest for other activities, such as feeding. Serial drop in temperatures could be due to predators, cars or displaying males disturbing the female. In Uzbekistan, Launay *et al.* (1997) found that the presence of displaying males in the vicinity of the nest was obviously disturbing for the nesting female.

On an average, a female will leave her nest 5.2 ±1.7 times (3 to 9 times) a day for periods from 8 to 26 minutes (average: 17.4 ±5.3 min). The total daily duration of these activity periods varied from 50 to 134 minutes (average 86

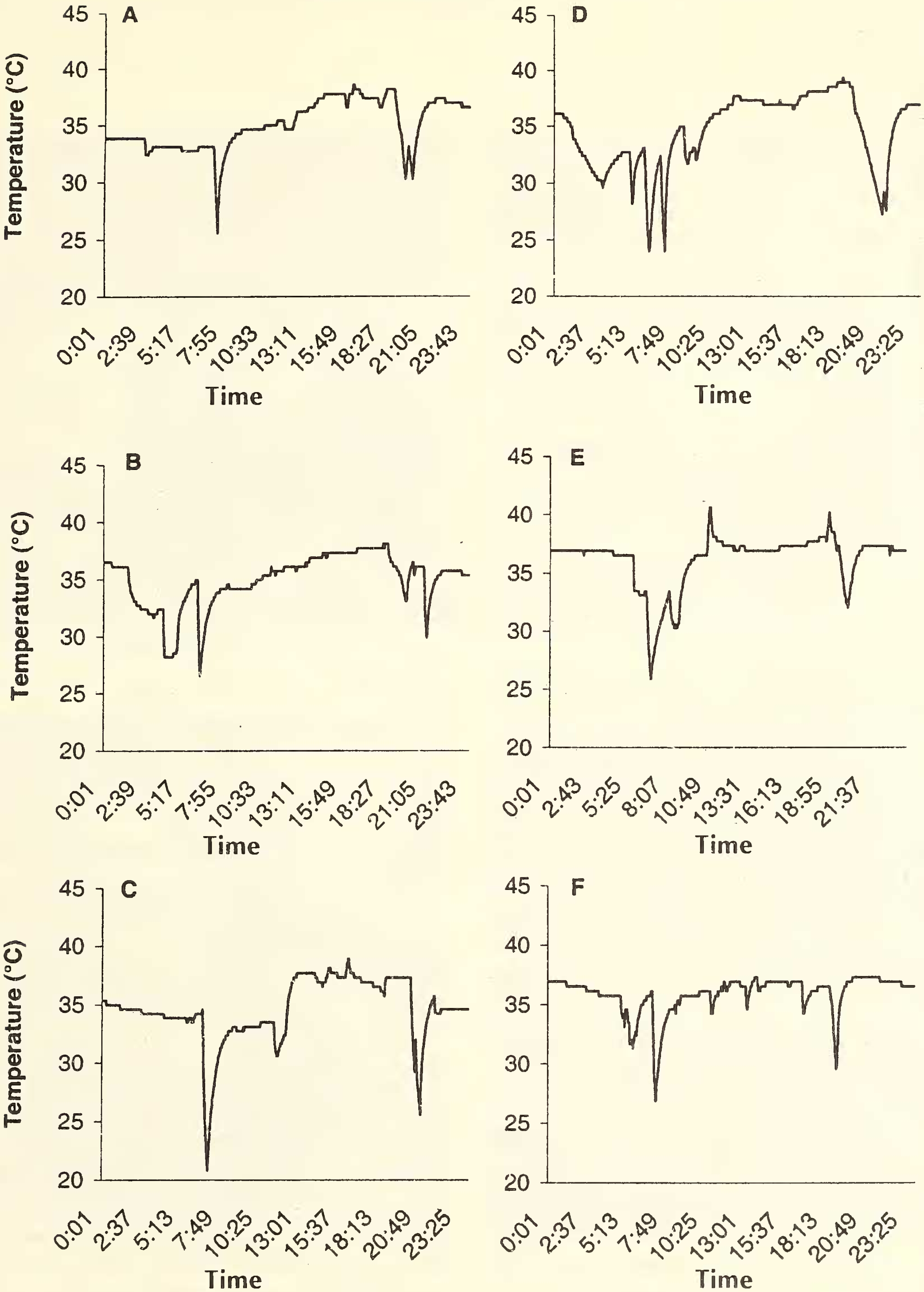


Fig. 1: Daily egg temperature at one houbara nest as relayed by the logger egg (A: hatching day – 11, B: hatching day – 10, C: hatching day – 9, D: hatching day – 3, E: hatching day – 2, F: hatching day).

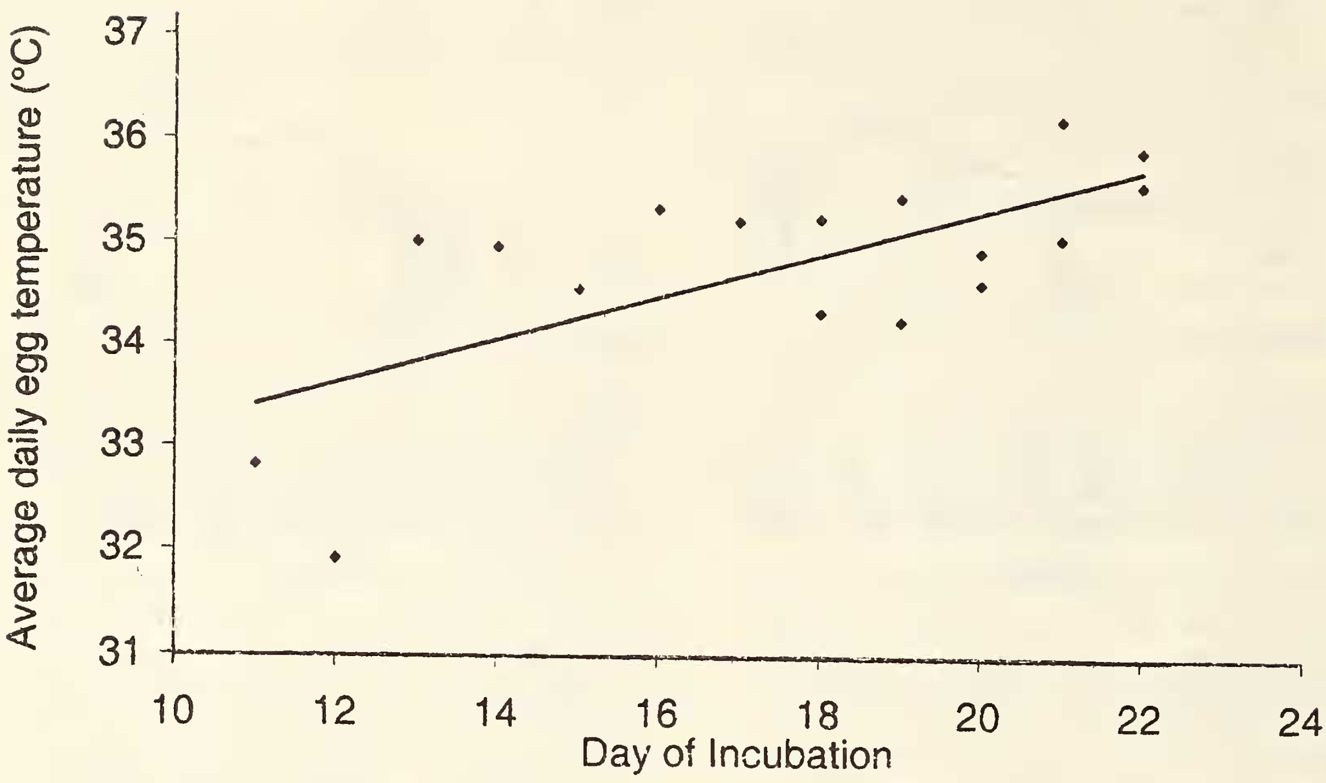


Fig 2: Linear regression of the average daily egg temperature during the incubation stage on the days of incubations (two nests).

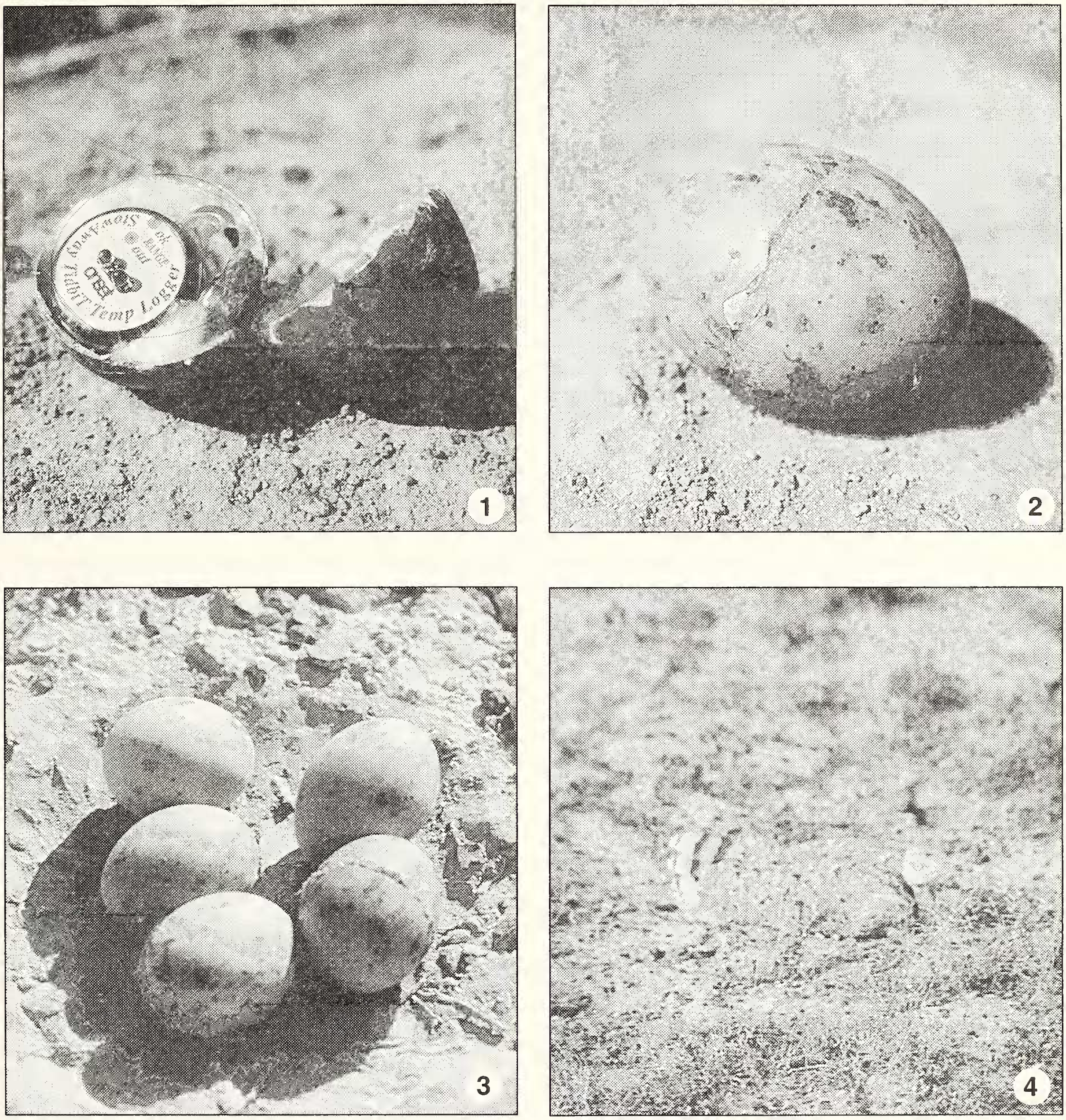
±23 min), independently of the air temperature (r^2=0.100, df=16, F=1.6, NS).

Activity periods normally occurred between 0613 and 1005 hrs in the mornings, and between 1845 and 2213 hrs in the evenings (Anova: F = 7.76, d.f. = 67, $p < 0.001$) making a bimodal daily activity pattern (12 days out of 17). In this respect, the activities of an incubating female were not different from those of non-breeding birds (Combreau and Launay 1996).

During incubation, the female spent 94 ±2% of her daily time on the nest. This observation matches that of Verbeek (1972), who recorded the activity of yellow-billed magpies (*Urocissa flavirostris*) in the field and found that females spent an average of 92.3 % of daily time on the nest. The temperature relayed by the logger showed successive variations of very small amplitude (0.4 °C) when the female sat on the nest. However, on the day of hatching, the data logger relayed many variations of amplitude in the range of 1 to 2 °C, suggesting a change in behaviour (Fig. 1F). Such variations of temperature were observed 8 times for one nest and 9 times for the other. These changes in the egg temperature were not interpreted as activity periods. We believe that the bird stayed on the nest all the time, but kept turning the eggs to facilitate the hatching.

The egg temperature measured 15 minutes after a possible disturbance by a car was found to be positively correlated to the distance from the car to the nest (r^2 = 0.158, F = 10.5, d.f. = 57, p = 0.002). The effect was restricted to a radius of 500 m around the nest. A linear regression analysis for distances ranging from 500 m to 2 km showed no effect at all (r^2 = 0.0026, F = 0.41, d.f. = 155, NS). This suggests that the female houbara incubating a nest is sensitive to human presence in a radius of 500 m. This effect, however, is small, (r^2 = 0.158) and the female returns quickly to the nest when the disturbing factor has gone. This behaviour of leaving the nest in case of danger seems to be the rule, but there are numerous exceptions. A

Jianfang, Qiao *et al.*: Houbara *Chlamydotis undulata* PLATE 1



PICS: O. COMBREAU

Figs 1-4: 1. Details of the temperature logger egg; 2. The temperature logger egg ready to place in a nest; 3. The temperature logger egg placed in a nest with 4 eggs; 4. A female houbara incubating her nest containing the temperature logger egg

number of times, we have observed females which would stay on the nest with the car or even human beings in close proximity (10-20 m).

Egg temperature: The average egg temperature, when the female was on the nest, varied from 31.9 to 36.5 °C (average, 34.9 ±1.1 °C). When the female left the nest for her daily activity, the temperature of the egg dropped to an average minimum of 24.9 ±3.2 °C (19.9 to 28.8 °C) in the morning and 29.8 ±2.8 °C (25.6 to 33.5 °C) in the evening (t-test, t=2.2, d.f. = 12, P < 0.001). This difference in the egg temperature was most easily explained by the difference in the average air temperature that ranged from 14.5 ±3.2 °C in the morning to 23.6 ±3.9 °C in the afternoon.

As the incubation advanced, we observed a general increase in the daily average temperature of the egg from 31.91 to 36.18 °C (average 34.8 ±1.0 °C) (r^2 = 0.48, F = 13.8, d.f. = 16, P = 0.002). For both nests, daily average egg temperature was highest on or around the hatching day (Fig. 2). The most likely explanation is an increase in the average air temperature as the incubation advances (r^2 = 0.47, F= 13.1, d.f. =16, P = 0.002). This is confirmed by the strong relation observed between the daily maximum air temperature and the daily maximum egg temperature (r^2= 0.52, F = 16, d.f. = 16, P = 0.001). An increase in egg temperature as the incubation stage advances has also been observed in other bird species (Steven *et al.* 1997). In 1982, Ralph explained this as resulting from the heat production of the embryo, the changes in substrate thermal conductivity and the changes in nest air temperature.

Quite surprisingly, in twelve out of seventeen cases, when the female was incubating the nest, the temperature of the egg increased gradually from morning to afternoon. On an average, the temperature of the egg rose to a maximum of 36.4 ±1.9 °C in the morning and 38.1 ±1.4 °C in the evening (t-test: t = 2.1, d.f. = 16, p = 0.0011). No obvious biological reasons could explain these differences, and the most likely explanation would be the difference in air temperatures between morning and afternoon. For both nests, we observed occasionally an absolute maximum temperature in the range of 40.2-40.6 °C, attained gradually in 15 or 20 minutes. The temperature stayed high for about 30 minutes, then decreased gradually to a more normal temperature around 37 °C. Such high temperatures in an incubating egg raise concern about the survival of the embryos, which would surely be killed under artificial incubation at these temperatures. In our study, the thermodynamics of the logger egg was obviously different from that of natural eggs. Being empty of fluids, it probably gained and lost heat much faster than natural eggs, and responded more quickly to changes in ambient temperature or orientation of solar radiation. When the logger egg reached temperatures above 40 °C, the temperature of the natural eggs may have been within the normal range. This is confirmed by the production in 2 nests of 3 and 4 vigorous chicks from 4 and 5 eggs, respectively.

Conclusions

Placement of a data logger in an egg was a useful method for obtaining egg temperatures and behavioural information on the incubating houbara female. Moreover, the introduction of a transformed egg in a nest found in the wild did not affect hatching, suggesting that the effect on the incubation behaviour of the female was negligible. The logger constantly monitored the egg temperature, from which deductions on the female's behaviour could be made without long periods of observation in the field. However, sometimes it was difficult to interpret accurately the changes in the egg temperature in terms of the female's behaviour, especially when successive changes of small amplitude were observed. Further observations would be necessary to fully understand the female's activity on the nest.

Though interesting behavioural results were obtained, the inaccuracy (±0.4 °C) as well as the difference in thermodynamic characteristics of the logger egg curtails the interpretation in terms of the temperature of incubation in houbara. It is, therefore, difficult to make proposals for modifying the incubation parameters used in artificial conditions. However, the female does not tend to keep the egg temperature constant as is done in incubators in captive breeding programs. On the contrary, severe variations of temperature were commonly observed, causing no lethal effect on the embryo. It is suggested that such variation in the incubation temperature in captivity might be beneficial to the development and hatching success of the eggs.

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